

Synthetic Polymers in the Marine Environment

**WHAT WE KNOW
WHAT WE NEED TO KNOW
WHAT CAN BE DONE?**

Captain Charles Moore

Algalita Marine Research Foundation

Introducing...the one-way, throwaway can...late 1940's



**DRINK RIGHT FROM THE CAN:
NO EMPTIES TO RETURN**

Source: Can and Bottle Bills - CALPIRG,
Original Source Unknown

A FEW YEARS
EARLIER,

DURING
WWII,

THIS
BEHAVIOR
WOULD HAVE
BEEN
UNTHINKABLE
—AND
PROBABLY
ILLEGAL

**MY FATHER
AND
MOTHER
LIVED IN A
DIFFERENT
WORLD –
THE WORLD
OF THE
GREAT
DEPRESSION
AND WWII**



LIFE

MAGAZINE

The thesis of the article was that a housewife would be more efficient if she didn't have to spend time washing and putting away the dishes.

The idea that "WASTE SAVES TIME" was born, and has since firmly embedded itself in first world consciousness

1

9

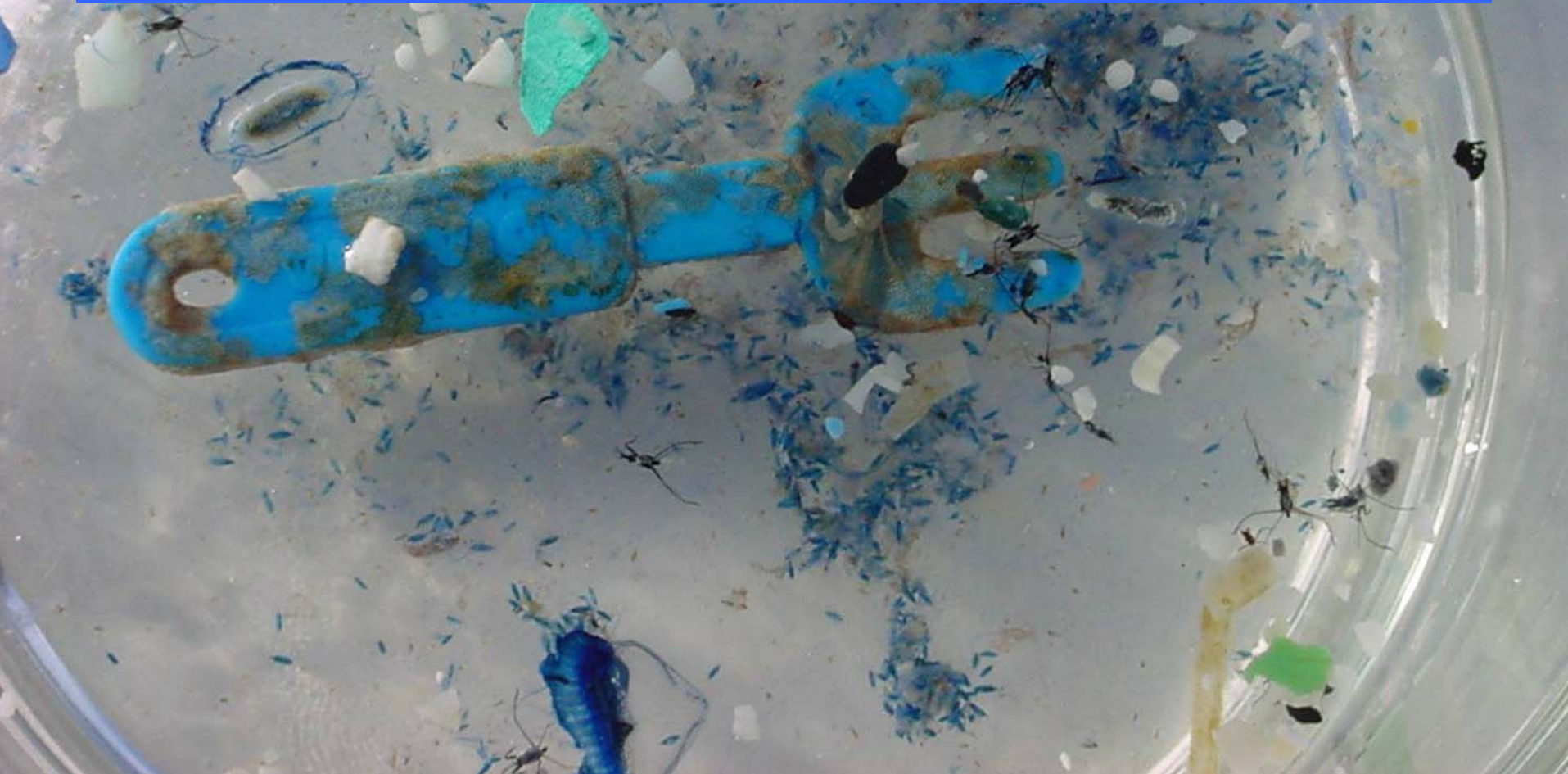
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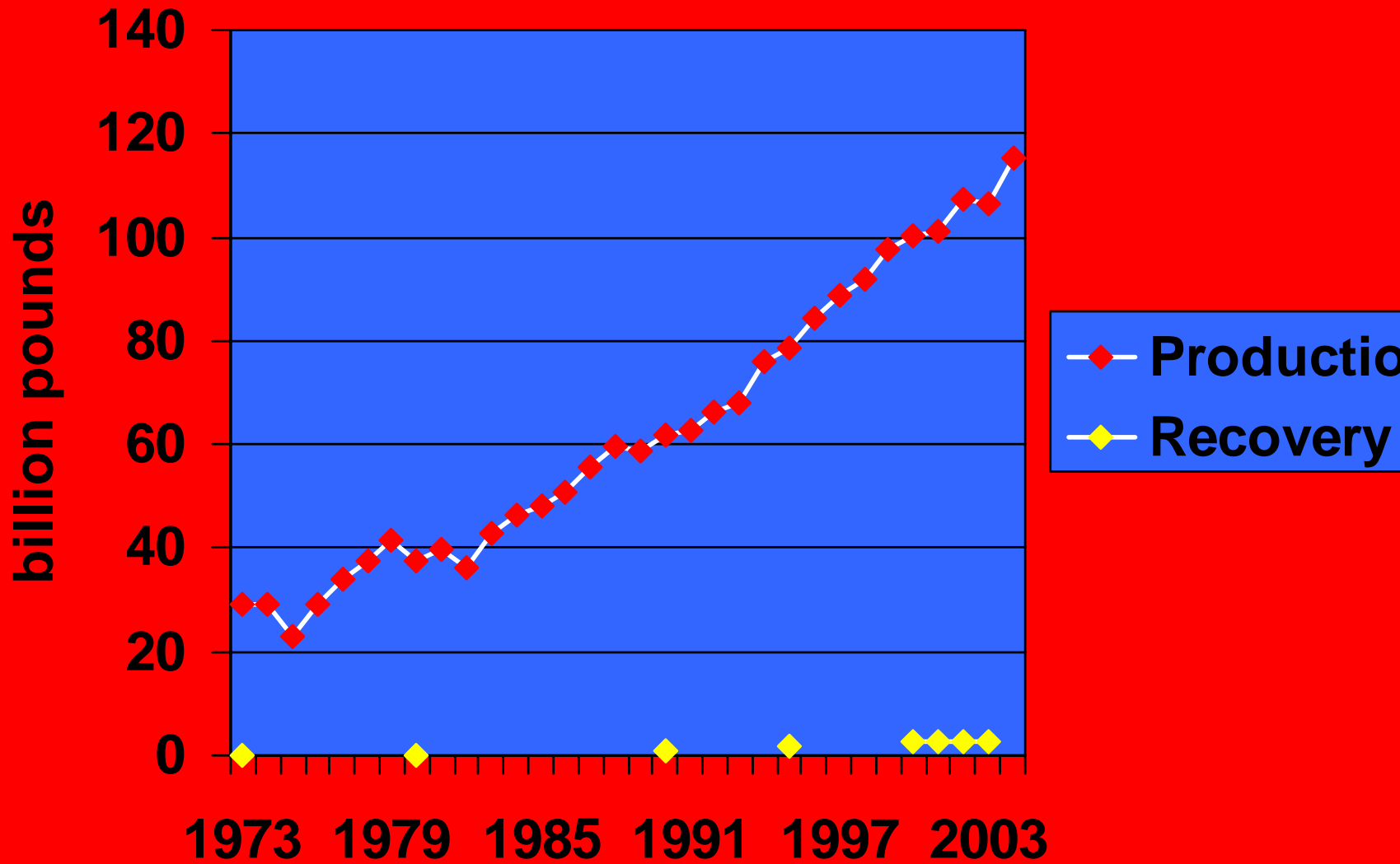
"Throwaway Living"



Throw Away Products Are Now
Mostly Plastic



Annual US Plastic Resin Production & Recover



Why isn't plastics recycling simple?

- Low melting point
 - Aluminum = 1,500 °F
 - Glass = 2,800 °F
 - Steel = 3,000 °F
 - Plastic = 210 - 480 °F
- Some scorch if heated = thermosets
- So many different types of plastic

HAWAII 5 FEB 2006





Kahalu'u Beach Park 2-5-06



URBAN THROWAWAYS ON THEIR WAY
TO “**AWAY**” >>> NAMELY; THE **OCEAN**
LONG BEACH, CALIFORNIA, 2005



HAKODATE 9 MARCH 2007



MUMBAI, INDIA



*Debris boom on Ballona Creek,
which carries Los Angeles' runoff*



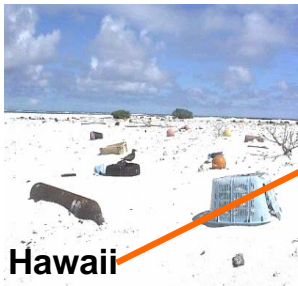
LAGOS, NIGERIA



MANILA HARBOR, PHILLIPINES

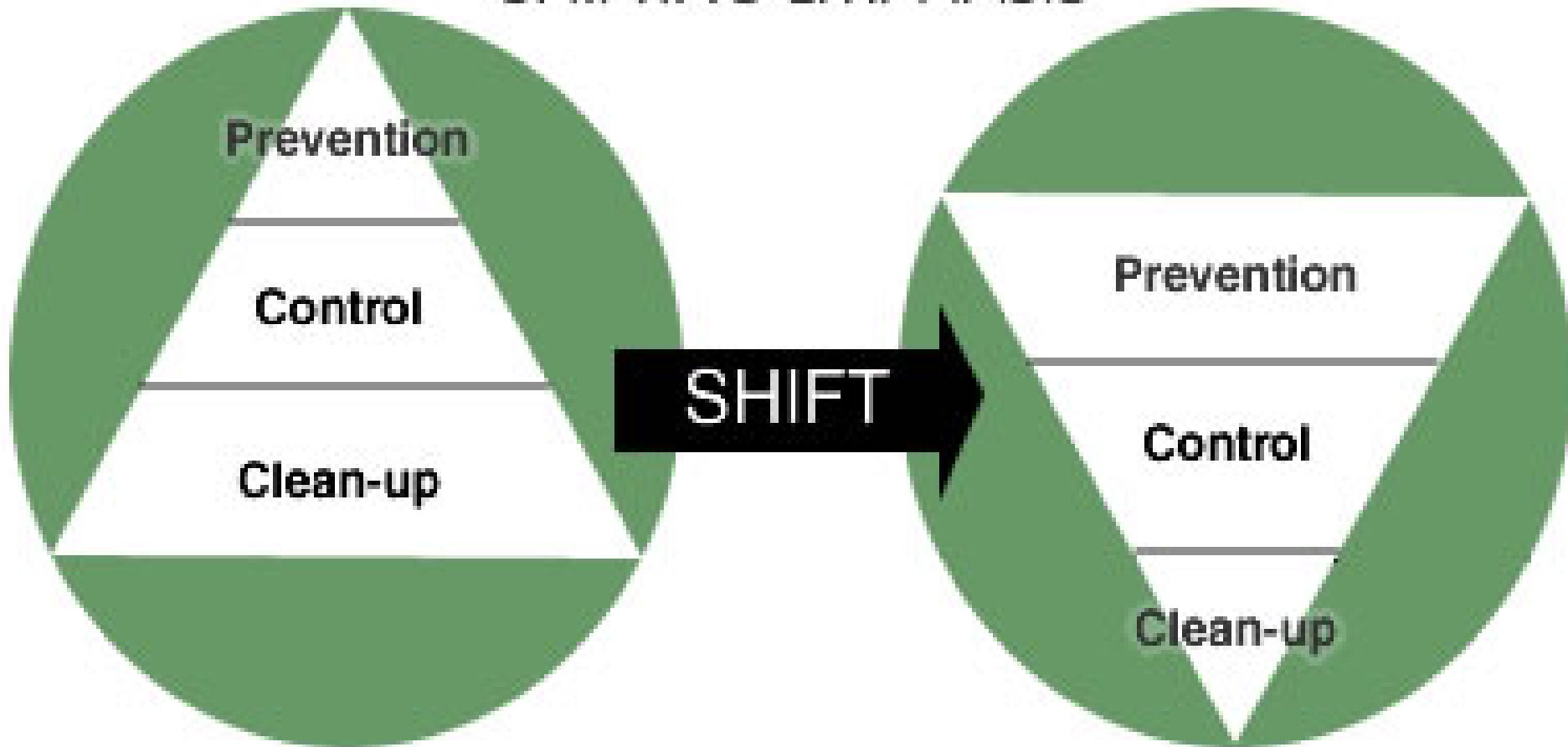


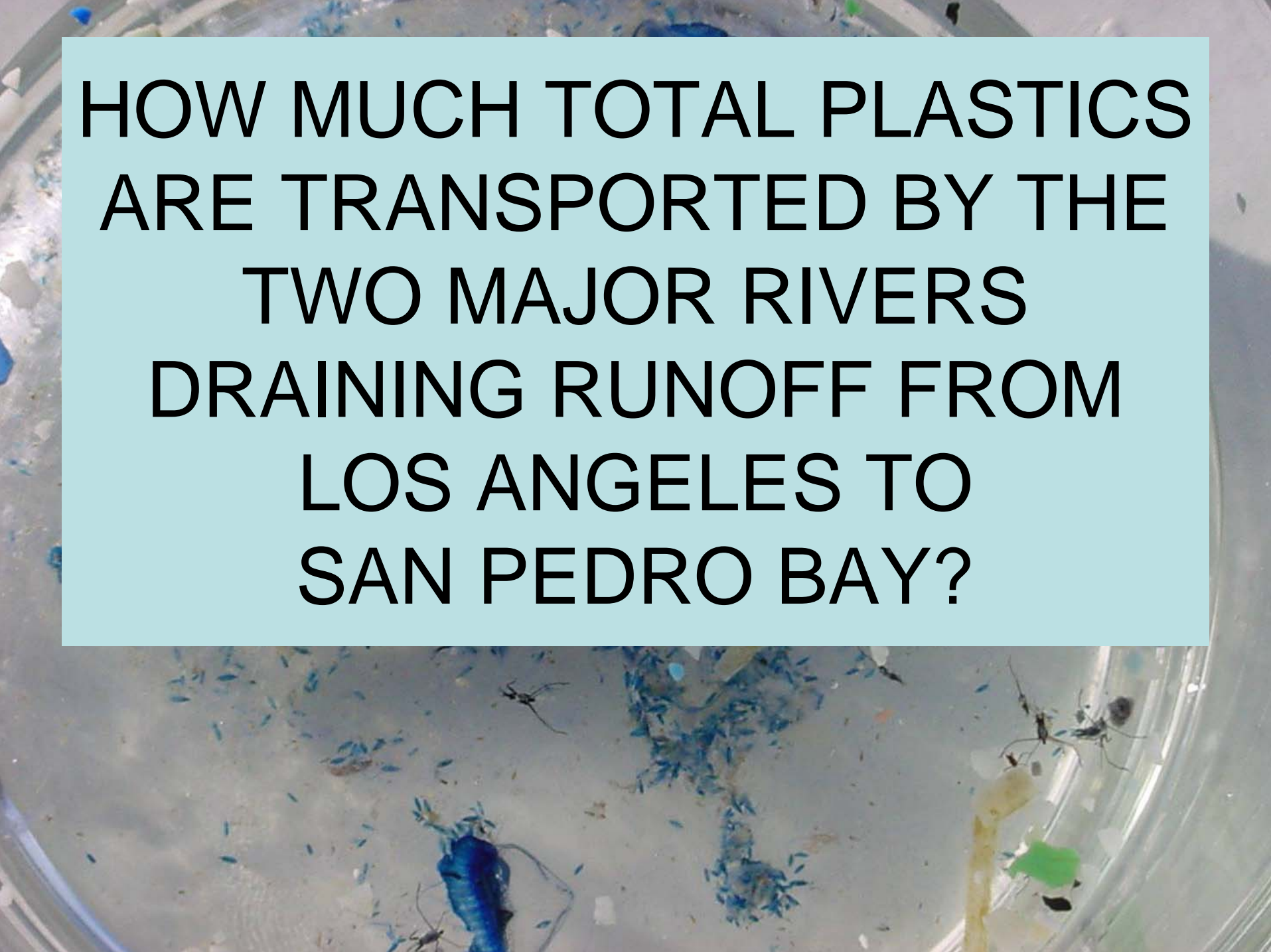
Throwaway Living = A Plastic Planet — Slide: Dr. Richard Thompson



As unintended consequences of saving time by wasting and polluting cost us more, our emphasis must shift

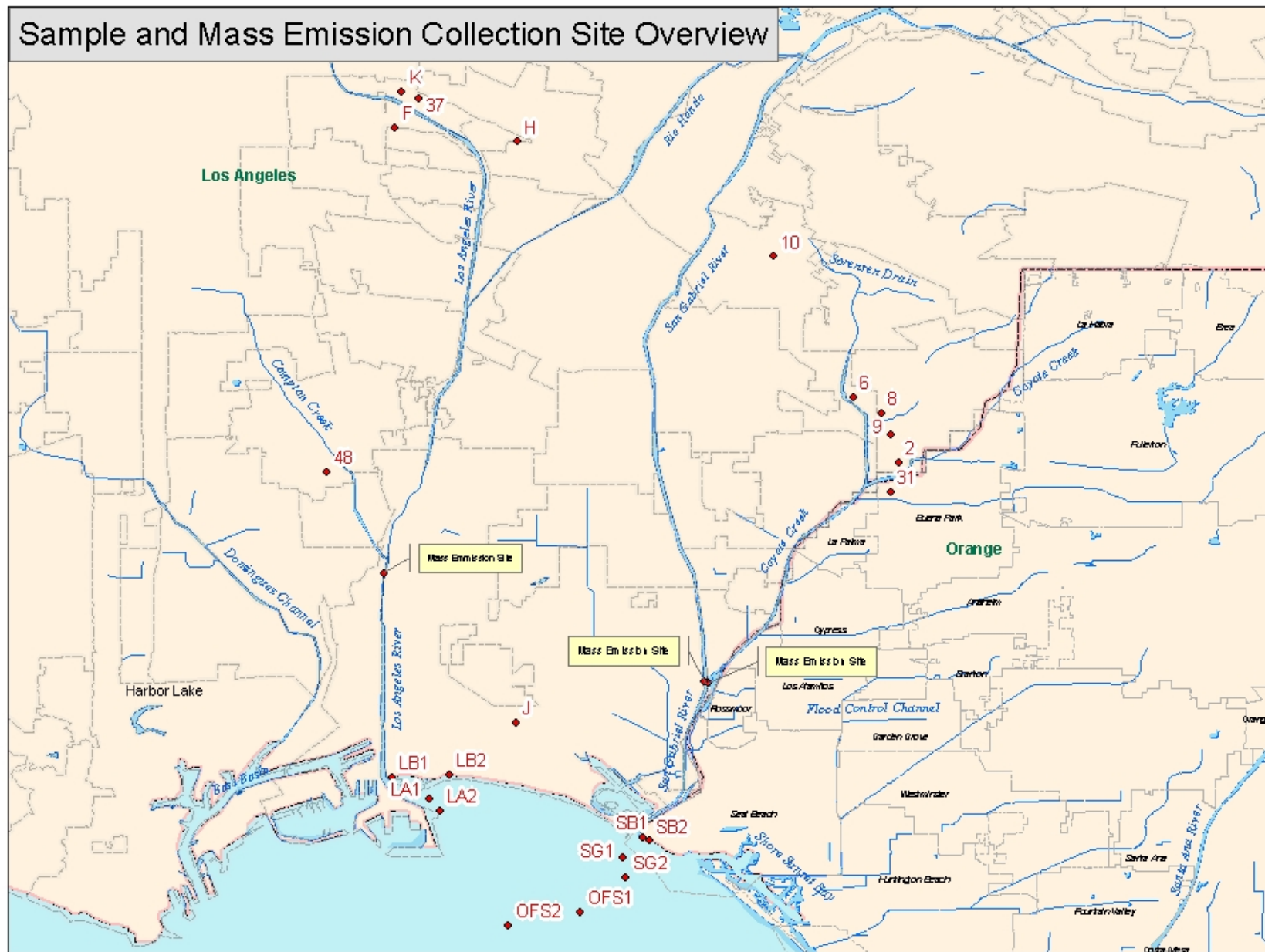
SHIFTING EMPHASIS



The background of the image is a photograph of a petri dish containing a water sample. The water is light blue and contains numerous small, dark blue, thread-like particles, likely microplastics. Several small, dark insects are visible on the surface of the water. A larger, blue, segmented object, possibly a larva or a piece of plastic, is visible in the lower left. A yellowish, fibrous object is visible in the lower right. The text is overlaid on a light blue rectangular background in the center of the image.

**HOW MUCH TOTAL PLASTICS
ARE TRANSPORTED BY THE
TWO MAJOR RIVERS
DRAINING RUNOFF FROM
LOS ANGELES TO
SAN PEDRO BAY?**

Sample and Mass Emission Collection Site Overview



SWRCB Number 03-084-554-0

Site Location Source: Algalita Marine Research Foundation

Features Data Source: TIGER Census 2000

0 1 2 4 6 8 10 Miles







DRY CONDITIONS



A photograph showing two workers on a sandy beach during heavy rain. The worker on the left is wearing a red life vest and yellow pants, holding a long pole. The worker on the right is wearing a yellow safety vest and dark pants, pulling a rope. The water is turbulent and splashing, with many whitecaps visible. The beach is covered in sand and some debris.

HEAVY RAIN CONDITIONS

THREE DAY TOTAL

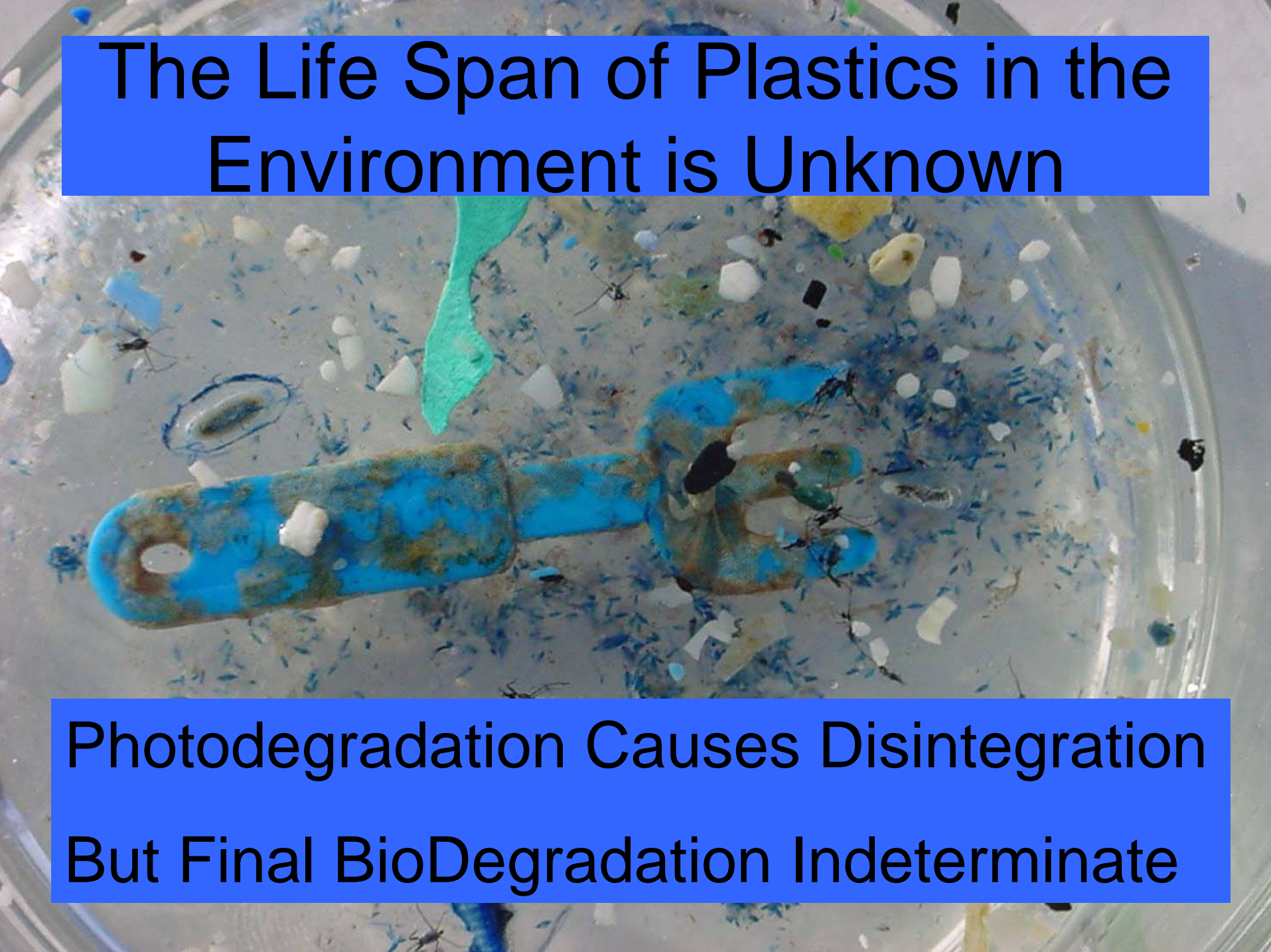
- PLASTIC PARTICLES LESS THAN 4.75MM, BUT GREATER THAN 1MM
2,046,664,600
- PLASTIC PARTICLES AND WHOLE OBJECTS GREATER THAN 4.75MM
287,783,600
- TOTAL PLASTICS FROM THE TWO MAIN LA RIVERS TO THE OCEAN IN TWO WET AND ONE DRY DAY***** 2.3 BILLION***

Number of Pellets in 3 Days

- **236,864,000**
- **11.6% of <5mm plastic debris**
- **10% of total debris**

The Life Span of Plastics in the Environment is Unknown

Photodegradation Causes Disintegration
But Final BioDegradation Indeterminate



Common snapping turtle, at least 15 years old. Crawled into a plastic bottle ring as young, her shell then constricted by the ring. Spinal cord partly unprotected.

Photo: ©Dino Ferri. Web site:

<http://www.auduboninstitute.org/zoo/index.htm>

Snapping turtle
June, 2000



Additives Can Be Very Effective in Delaying Photodegradation





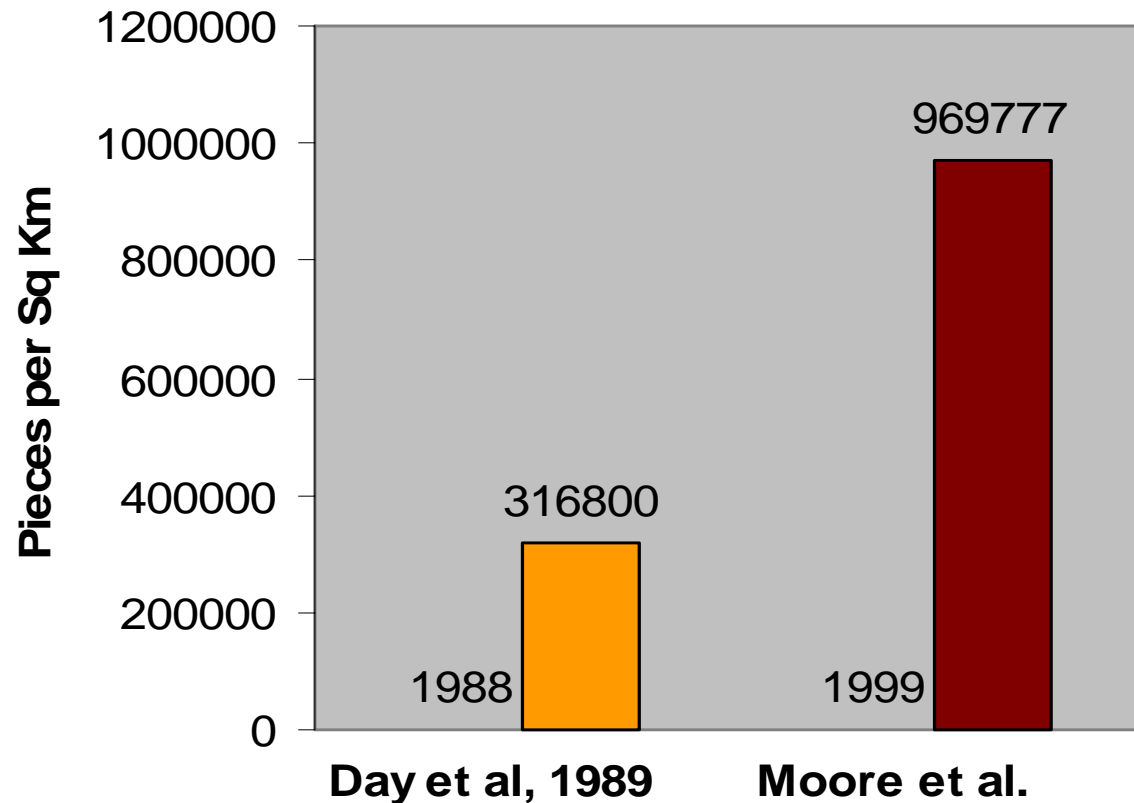
In the Southern Ocean, Plastic Debris Increased 100 Fold in 1990s

- In Coastal Japan During 1970s, Dr. Ogi Found Plastic Particle Densities Increased 10 Fold in **Ten** Years
- In the Same Area During 1990s, Ogi Found Plastic Particle Densities Increased 10 Fold every **Two** to **Three** Years

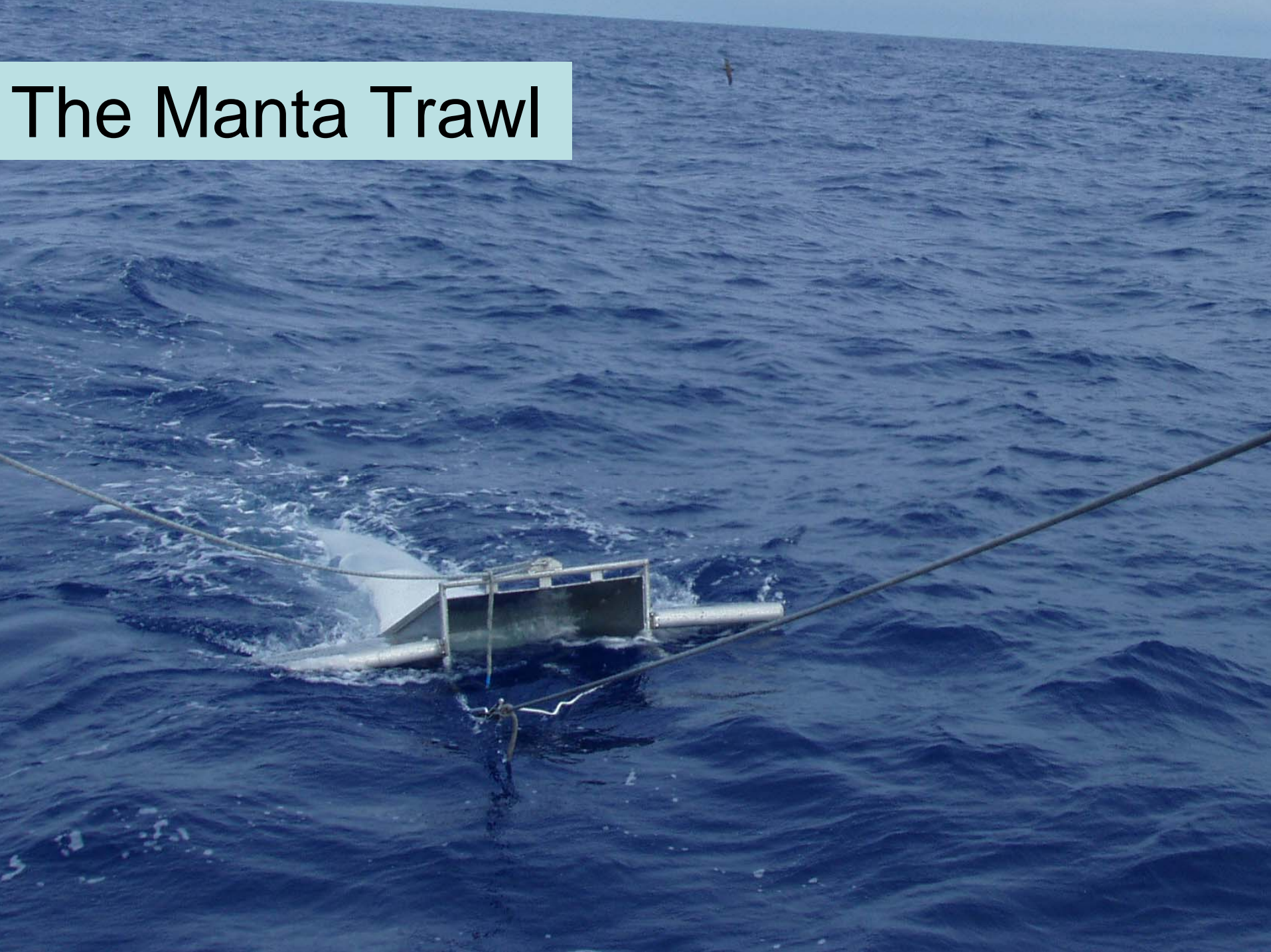
Maximum plastic particles tripled in last 10 years-North Pacific Gyre

1988	316800
1999	969777

Maximum Density



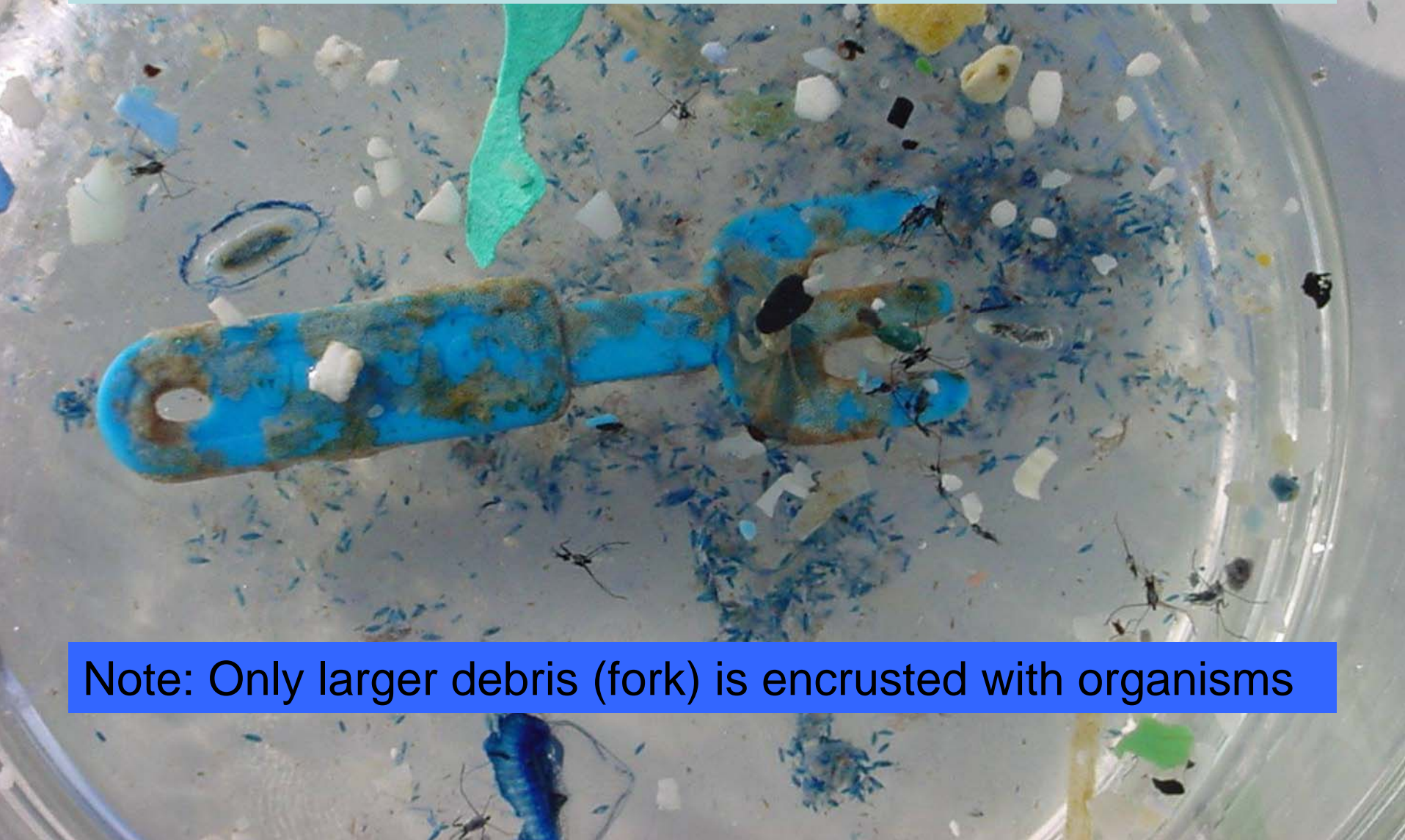
The Manta Trawl



1 mile
Zooplankton
Trawl
Cyre

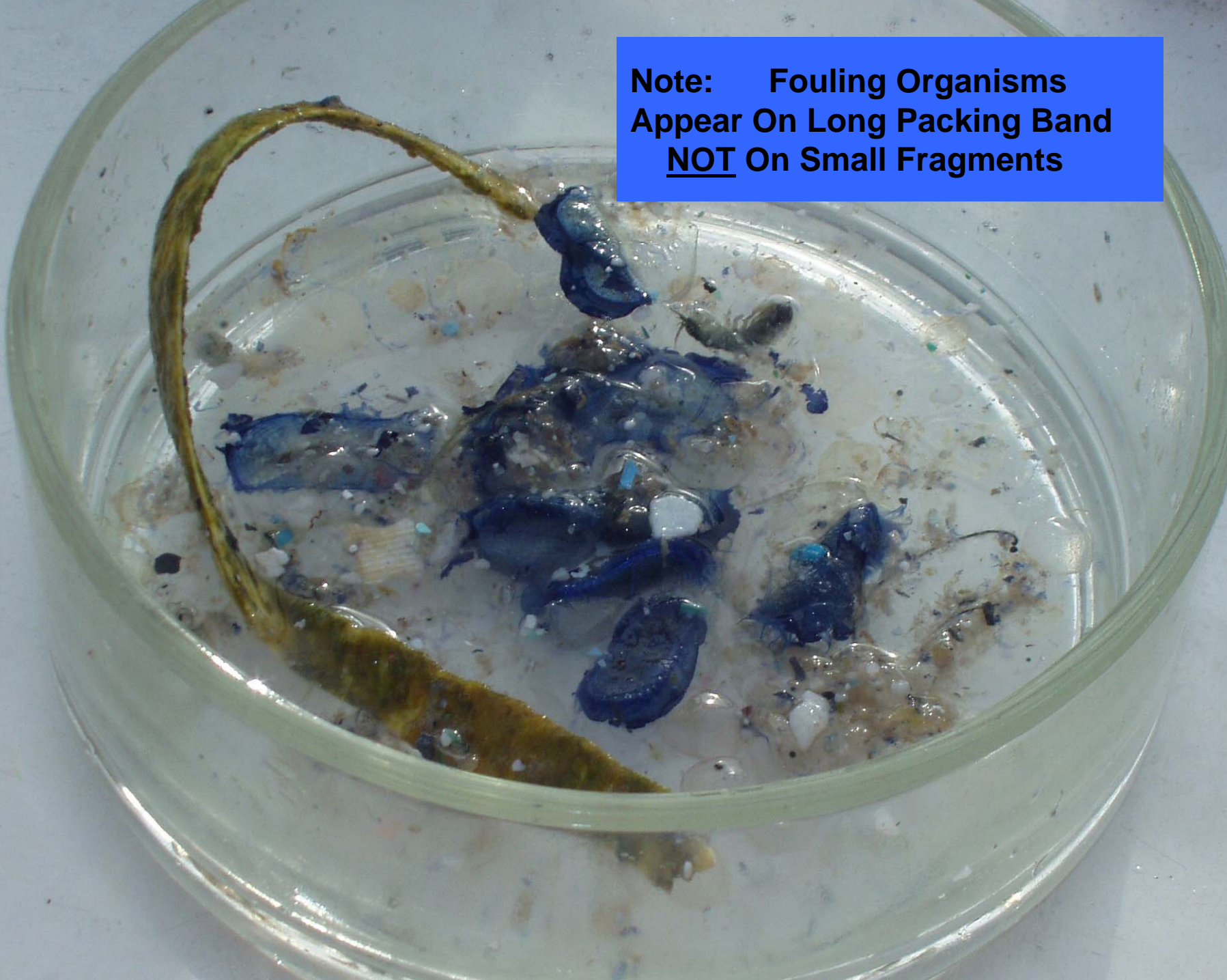


Gyre Samples with a ratio greater than Six to One Plastic to Plankton

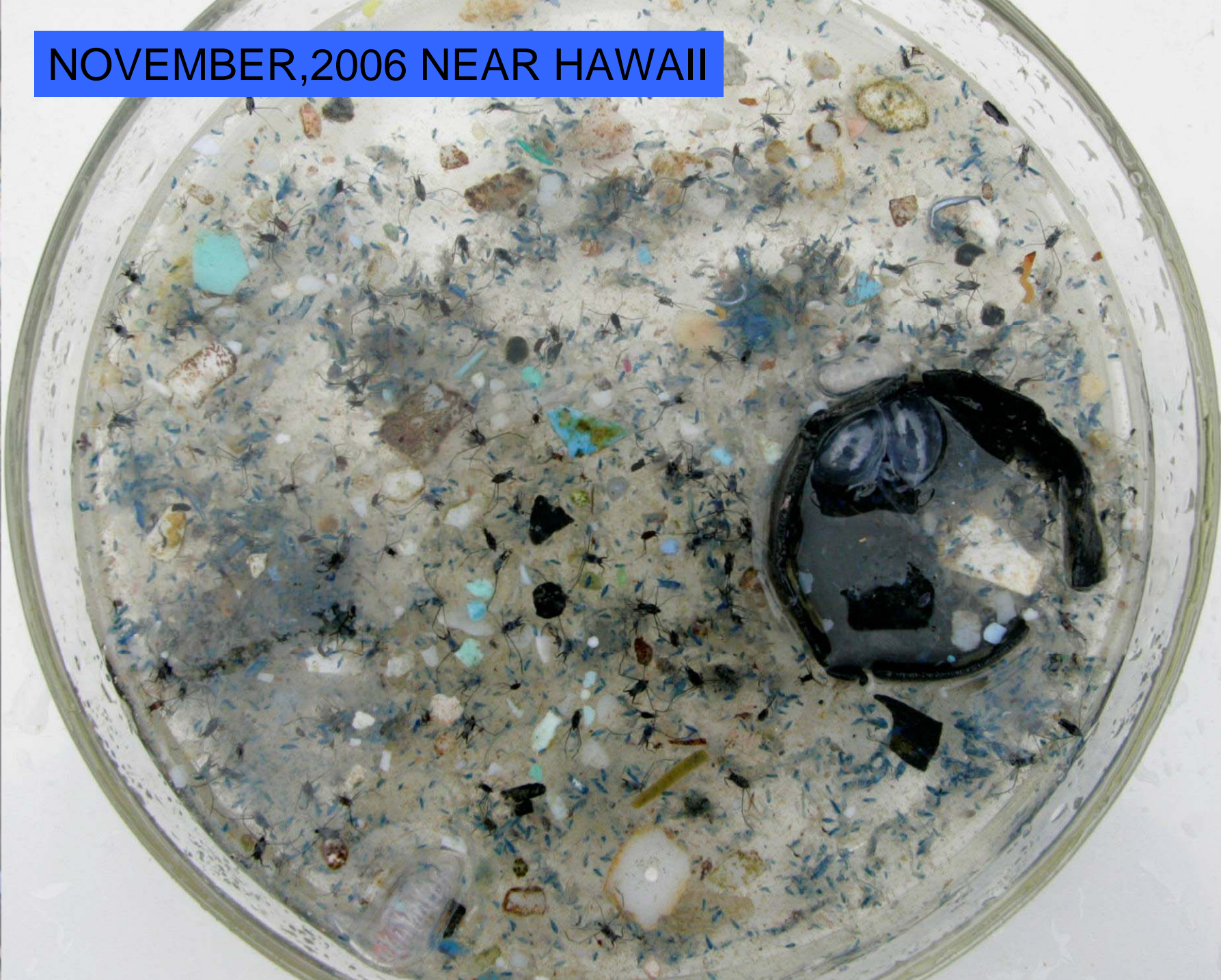


Note: Only larger debris (fork) is encrusted with organisms

**Note: Fouling Organisms
Appear On Long Packing Band
NOT On Small Fragments**



NOVEMBER, 2006 NEAR HAWAII



Three Salps--Two appear to have ingested Styrofoam



Ingested plastic particle appears to be near maximum possible size



Poly line with nearby fragment



Excised Line Fragment



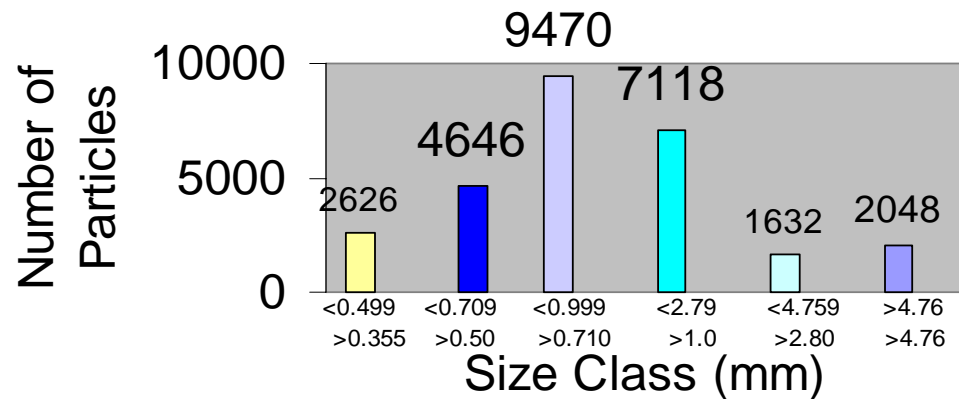
Salps Are The Ocean's Most Efficient Vacuum Cleaners



Summary of neuston plastics caught in manta trawl, summer 1999 **BY SIZE CLASS**

SizeClass (mm)	Stations											Total
	1	2	3	4	5	6	7	8	9	10	11	
>4.76	1	178	69	27	196	146	71	188	247	402	523	2048
<4.759 >2.80	110	111	15	27	328	170	75	107	98	280	311	1632
<2.79 >1.0	796	785	86	242	602	427	562	940	1340	1119	2571	9470
<0.999 >0.710	423	844	52	149	227	263	463	856	1366	335	2140	7118
<0.709 >0.500	637	448	56	155	121	440	814	817	177	981		4646
<0.499 >0.355	318	225	58	89	73	49	22	292	645	65	790	2626
TOTAL	2285	2591	336	689	1455	1495	2007	3200	3873	3182	6335	27448

Particle Size Distribution



Plastic Resin Pellets
Accumulate Hydrophobic
Pollutants up to 1 million times
their Concentration in the
Surrounding Seawater

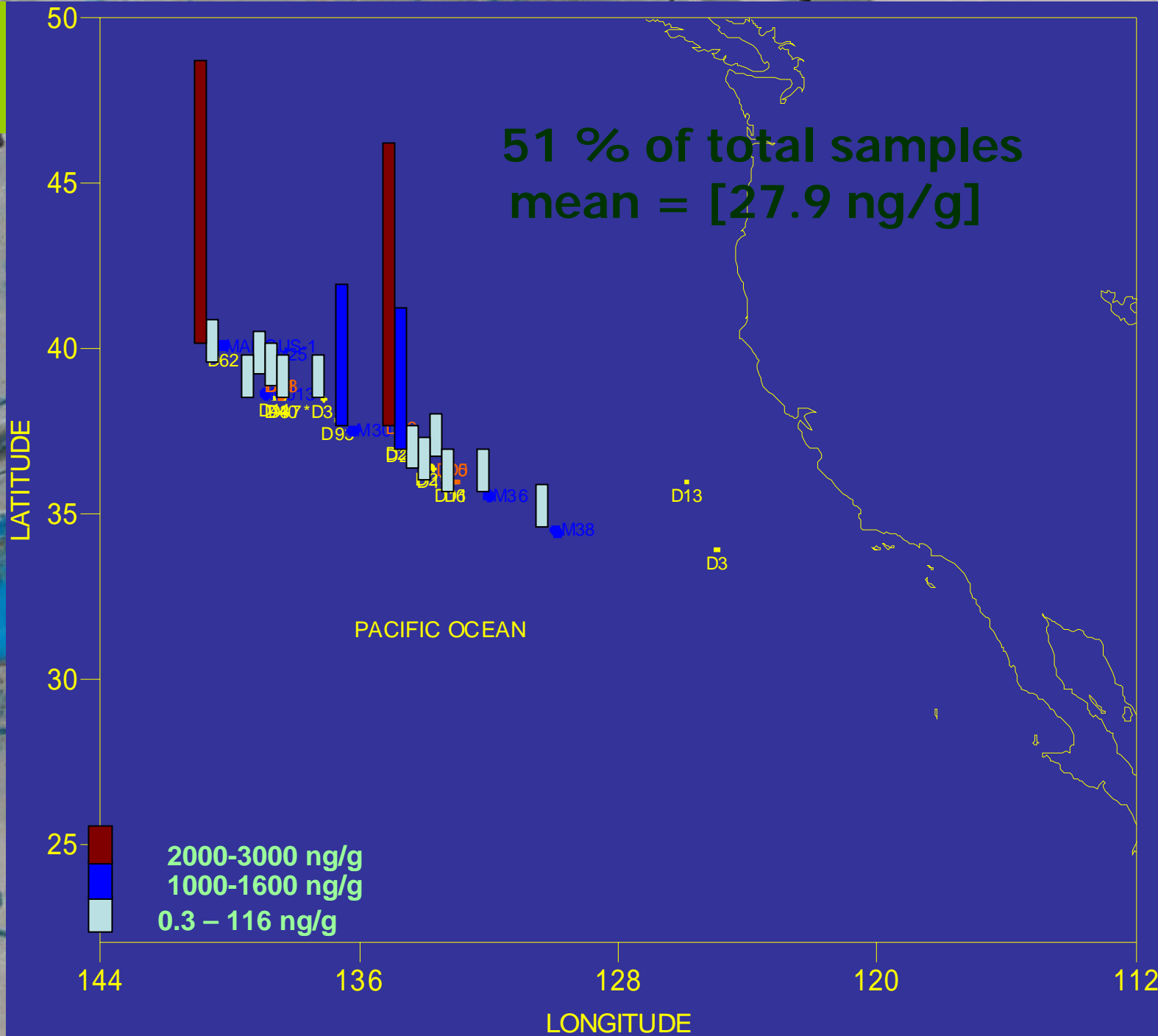


PCBS

3.2 –
2857
ng/g

PCBs limit
detection
(0.02 – 0.15
ng/g)

PCB-11,
PCB-28
PCB-40
PCB-52
PCB-66
PCB-101

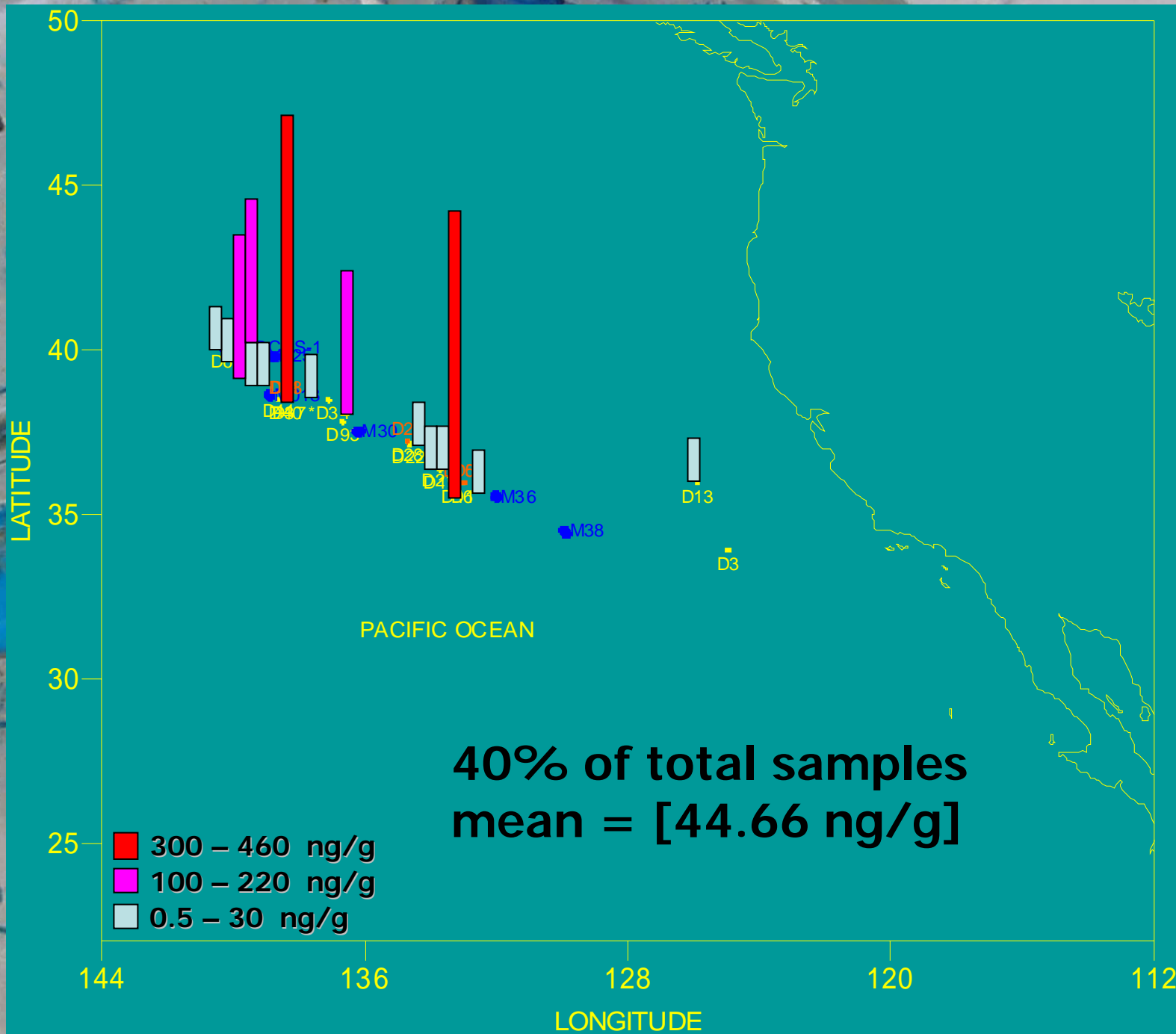


Pesticides

0.5 – 453
ng/g

Pesticides limit
detection
(0.03 – 2.03
ng/g)

- DDTs and its metabolites
- o,p-DDD
- BHC ($\alpha, \beta, \gamma, \delta$)

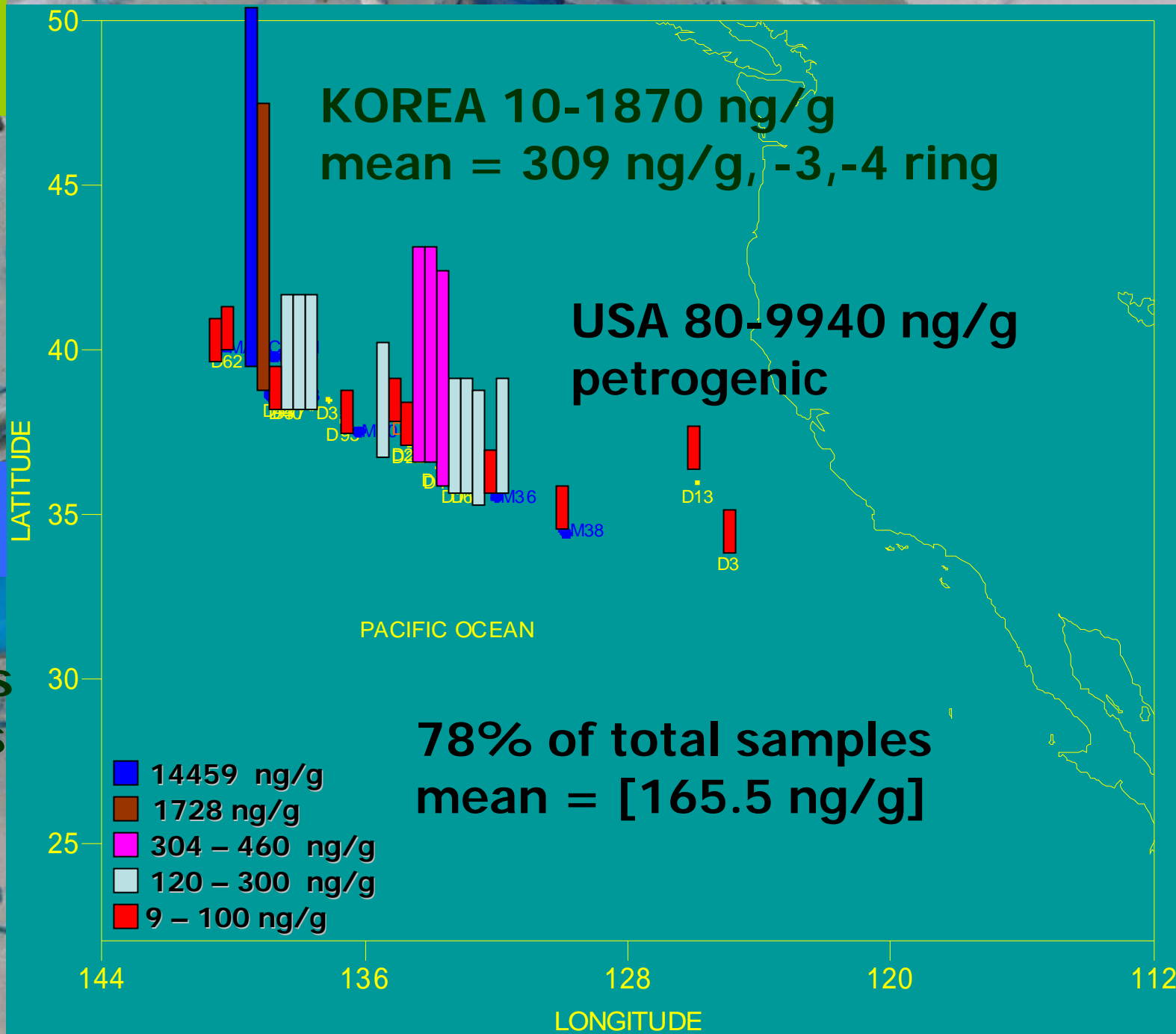


PAHs

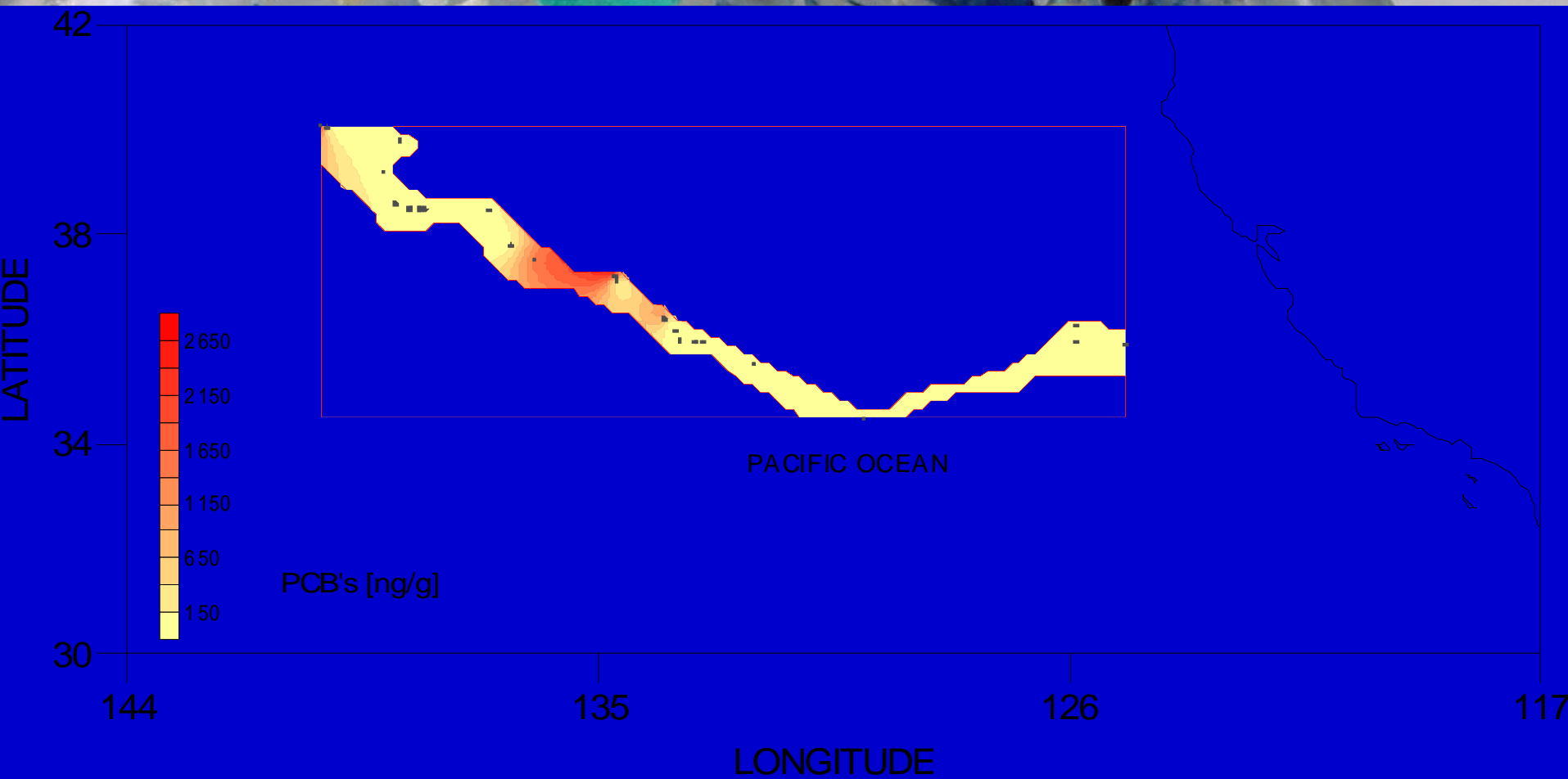
9.6 –
14459
ng/g

PAHs limit
detection
(0.05 – 0.8 ng/g)

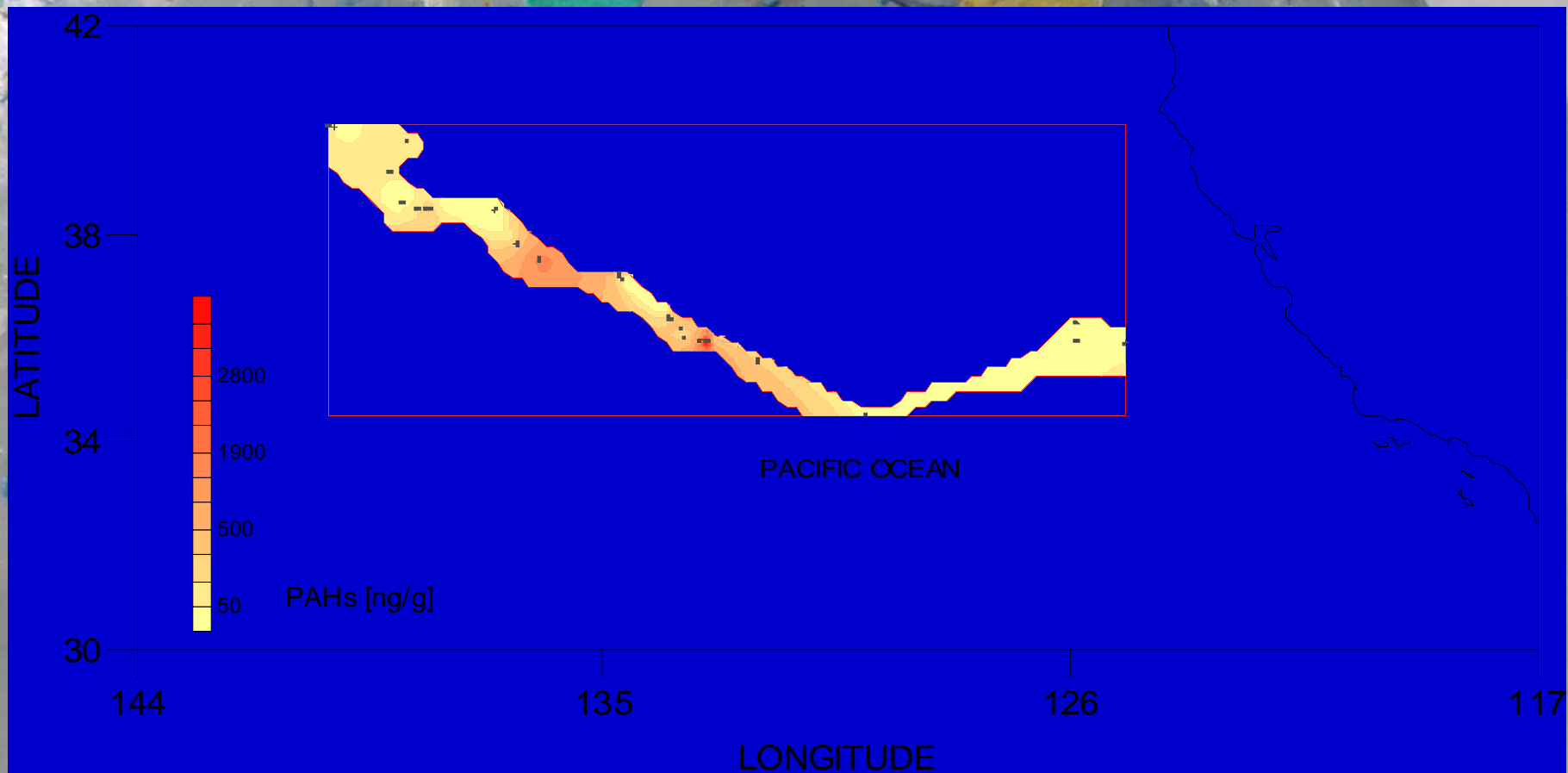
2,3,4 rings
congeners

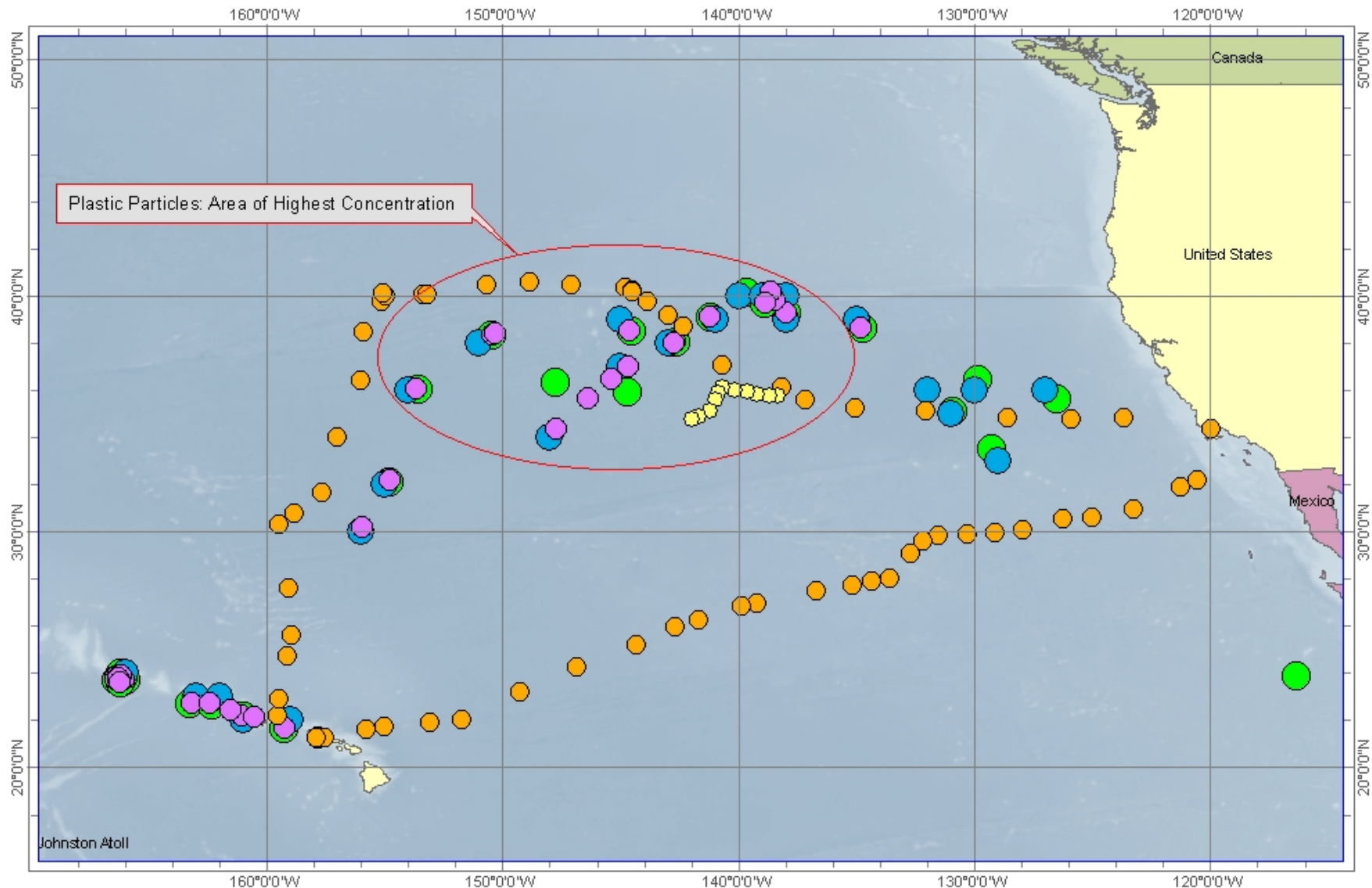


PCB CONCENTRATION



PAH CONCENTRATIONS





Collection Sites GPS Locations

- Gyre 1999 Manta Trawl
- Gyre 2000 Manta Trawl
- Gyre 2002 Manta Trawl
- Gyre 2002 Bojito 10m Trawl
- Gyre 2002 Bojito 30m Trawl

Overview Map of North Pacific Gyre

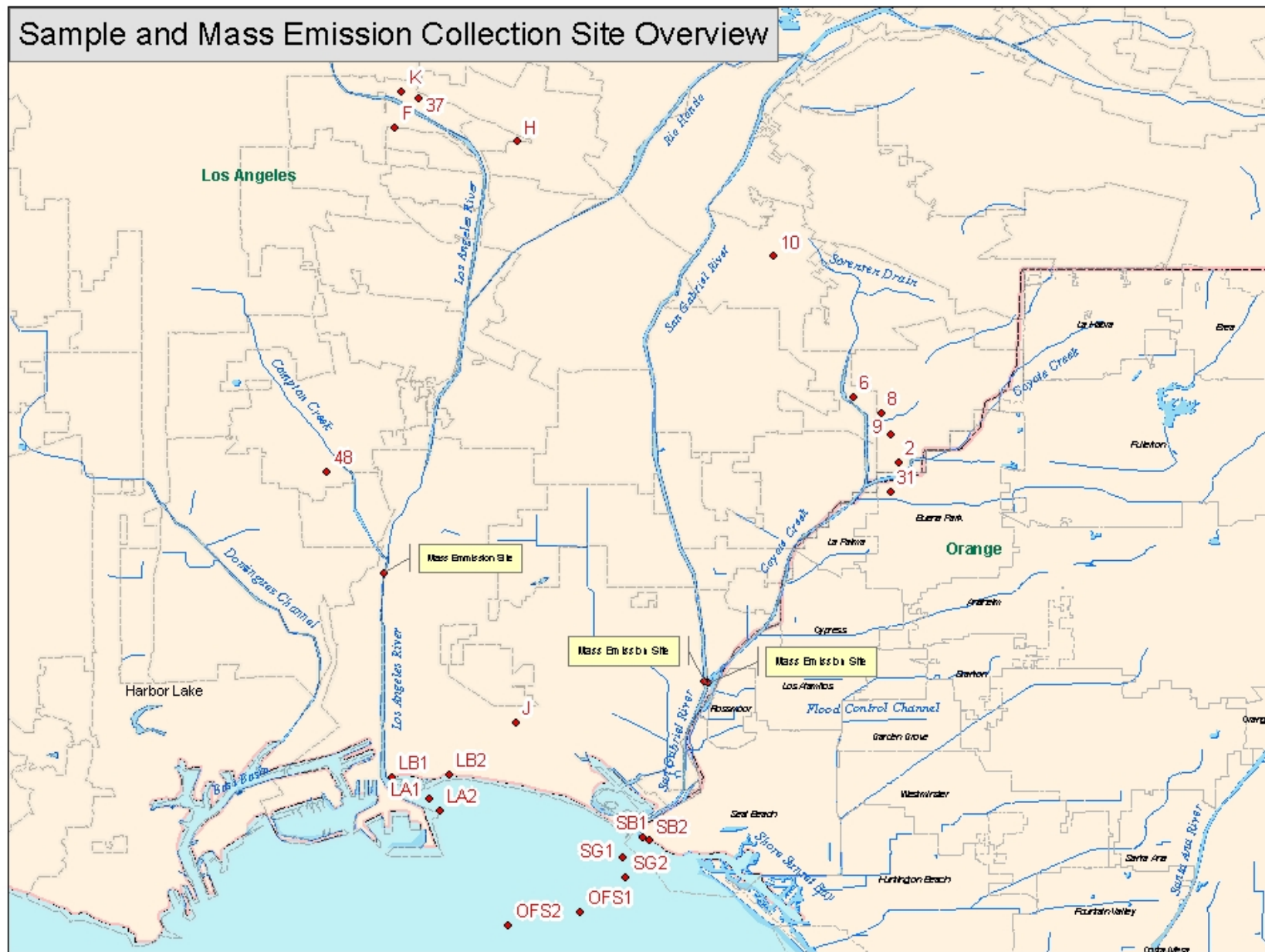


0 250 500 1,000 1,500 2,000 Nautical Miles

Data Sources: Algalita Marine Research Foundation, ESRI, NOAA and ETOPO2

Map Prepared by Veronica Rojas August 17, 2005

Sample and Mass Emission Collection Site Overview




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Site Location Source: Algalita Marine Research Foundation

Features Data Source: TIGER Census 2000

0 1 2 4 6 8 10 Miles

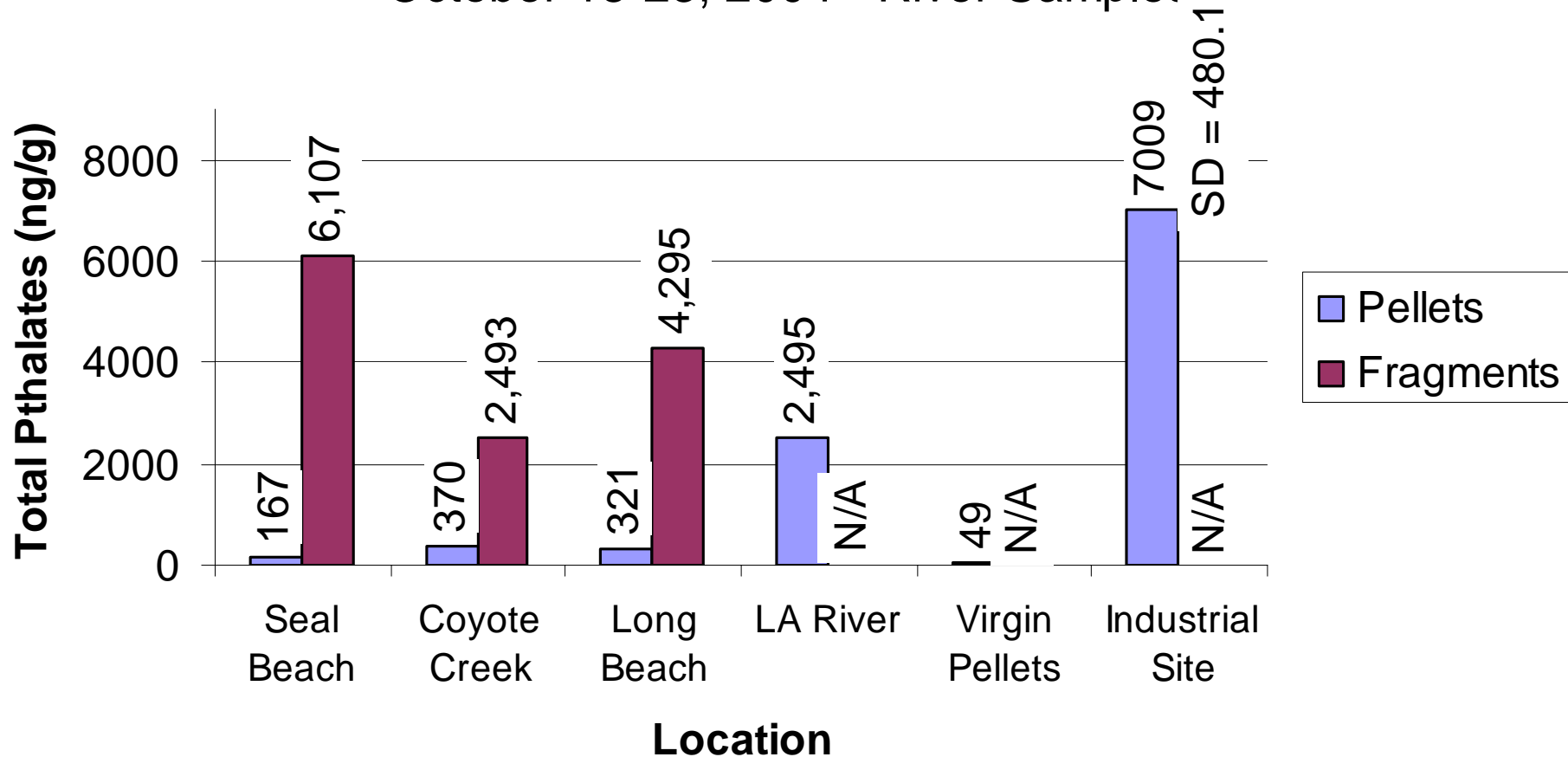


The background of the slide is a photograph of a petri dish containing a culture. The culture medium is light-colored and contains various blue and green bacterial colonies. A large, solid blue rectangular box is superimposed over the center of the image, containing white text.

**WE LOOKED AT
PHTHALATES ADDED TO
PLASTICS AT TIME OF
MANUFACTURE AND PAH'S
WHICH ARE ABSENT IN
VIRGIN PLASTIC PELLETS**

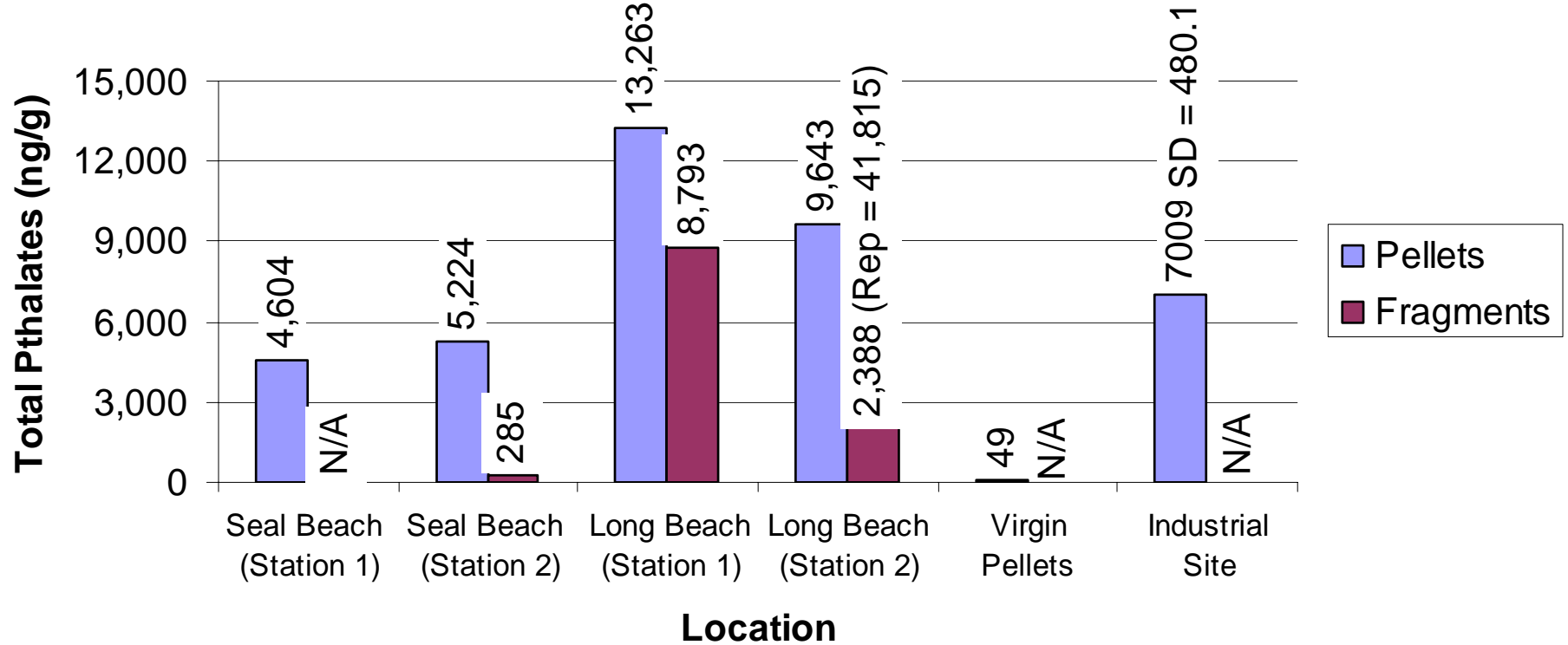
Total Pthalates (ng/g)

October 18-23, 2004 - River Samples



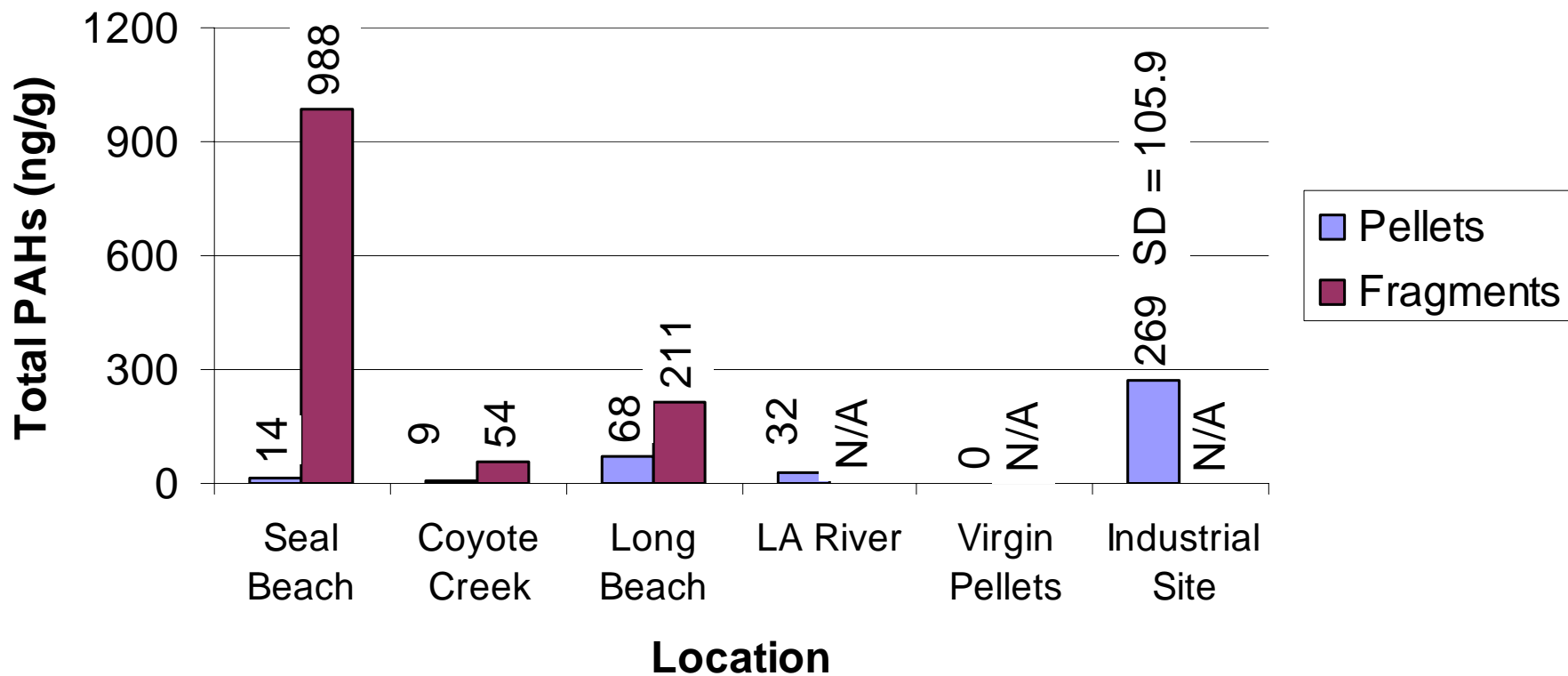
Total Pthalates (ng/g)

March 4, 2005 - Beach Samples

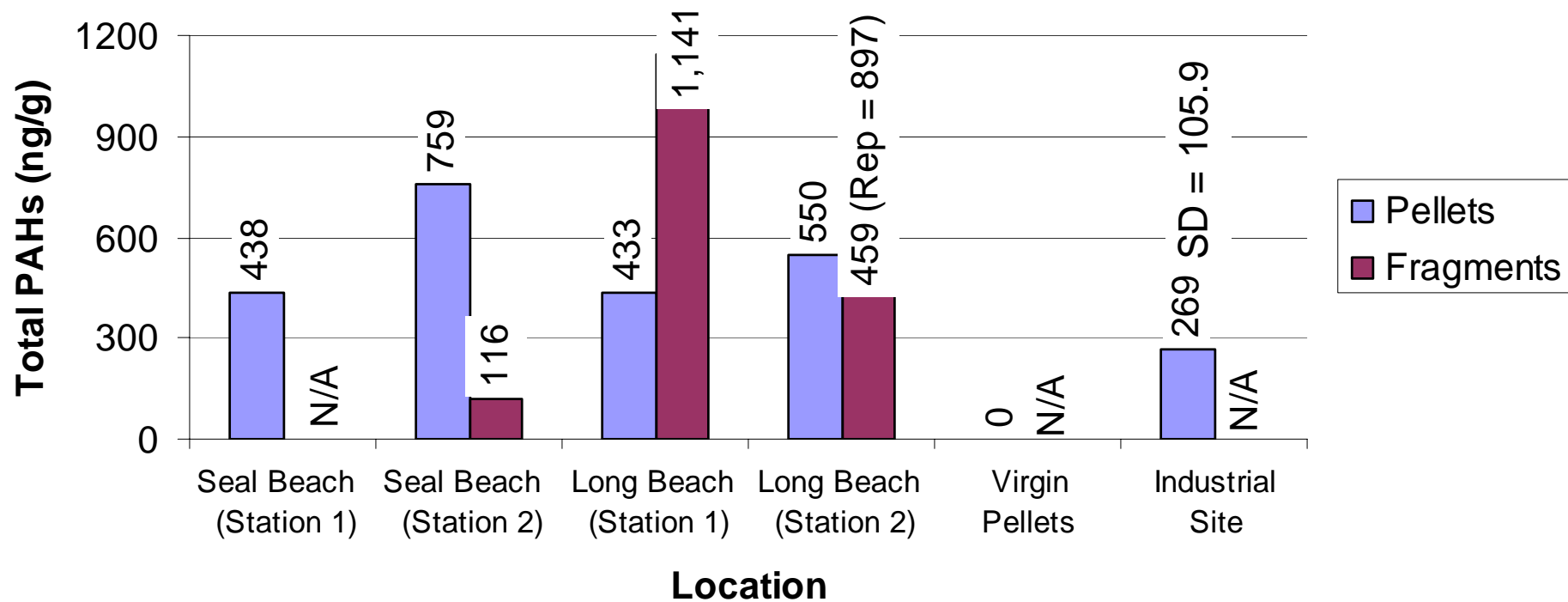


Total PAHs (ng/g)

October 18-23, 2004 - River Samples



Total PAHs (ng/g)
March 4, 2005 - Beach Samples



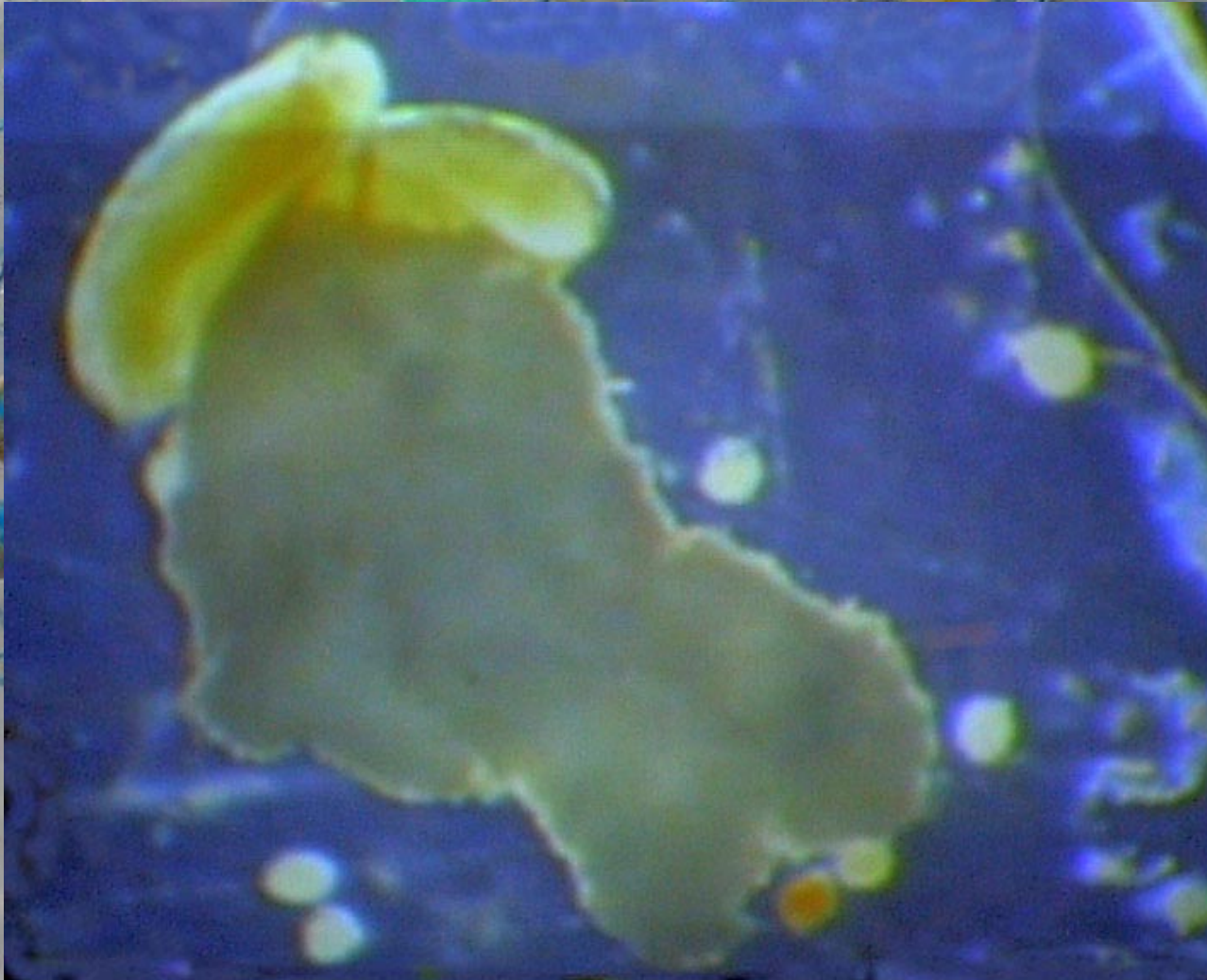
CONCLUSIONS

1. Phthalates were found in both pellets and fragments from field samples taken at river banks and beaches
2. Phthalates were found in virgin pellets
3. Phthalates were found in pellets from a transport facility parking lot catch basin

CONCLUSIONS

1. PAHs were found in both pellets and fragments from field samples taken at river banks and beaches
2. No PAHs were found in virgin pellets
3. PAHs were found in pellets from a transport facility parking lot catch basin

Colonized Plastic Particle attracts and transports food



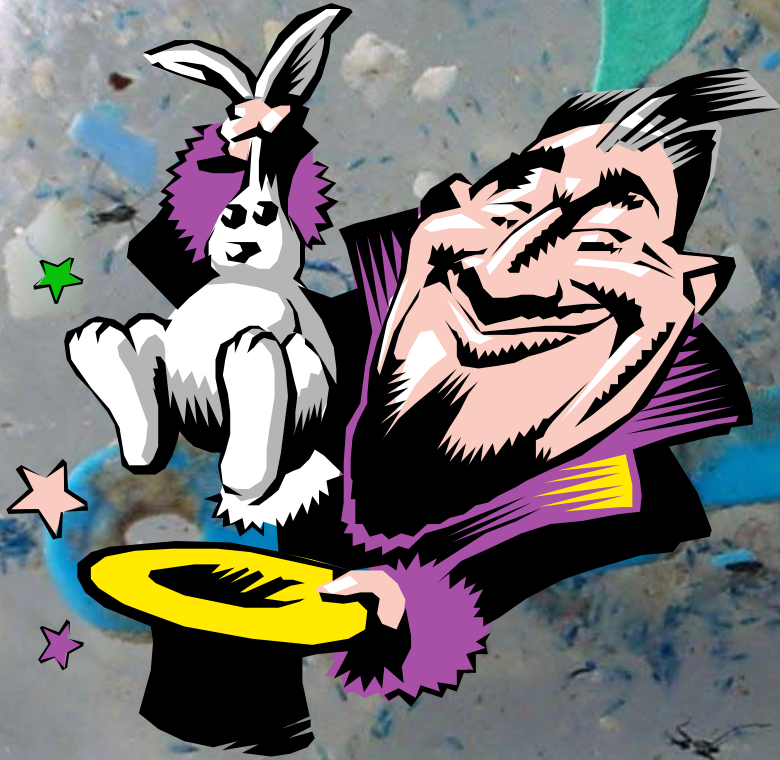
EXPANDED POLYSTYRENE BIT COLONIZED BY GOOSENECK BARNACLES







Estimated Plastic In All Oceans



2.5% of
Total
World
Output
Since
1955

100×10^6 metric tons



Four Main Hormone Mimics Associated with Plastics

1. Phthalates
2. Nonylphenols
3. Polybrominated Diphenyl Ethers
4. Bisphenol A

EVIDENCE FOR BIAS DUE TO SOURCE OF FUNDING IN ANIMAL STUDIES WITH BPA AT HUMAN EXPOSURE LEVELS (1997 - 2006)

SOURCE OF FUNDING	<u>STUDY OUTCOME</u>		
	HARM	NO HARM	
Government	138 (93%)	11 (7%)	149
Chemical Corporations	0 (0%)	12 (100%)	12
	138	23	161

vom Saal and Hughes, 2005
Environ. Health Perspect.

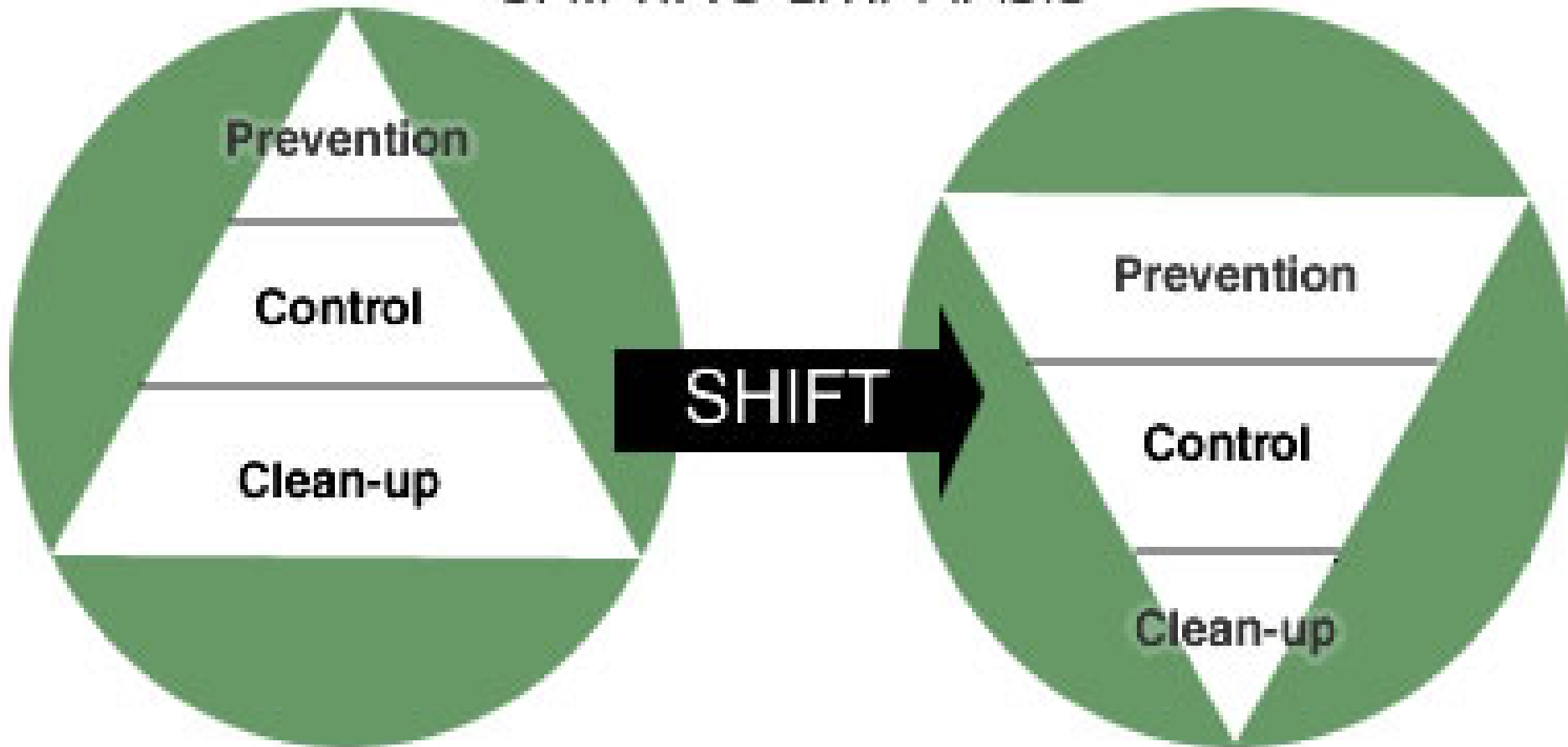
+ Over 80 *in Vitro* Studies
of Molecular Mechanisms

Efforts to Control Plastic Pollution Are Timid and Ineffective



As unintended consequences of saving time by wasting and polluting cost us more, our emphasis must shift

SHIFTING EMPHASIS



LINE ATOLL, HAWAII'S NORTHERNMOST ISLAND

Photos Copyright 2003 by Cynthia Vanderlip



KURE ATOLL 3500 MILES FROM

LOS ANGELES

1500 MILES FROM ALASKA

2000 MILES FROM JAPAN



Our Legacy?





ALGALITA MARINE RESEARCH
FOUNDATION www.algalita.org